TWO FOSSIL INSECT WINGS IN THE COLLECTION OF MR. JOHN MITCHELL, FROM THE UPPER PERMIAN OF NEWCASTLE, N.S.W., BELONGING TO THE ORDER HEMIPTERA.

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(Plate xxxv., and five Text-figures).

The two fossil insect wings dealt with in this paper were discovered by Mr. John Mitchell under somewhat remarkable circumstances, which are best explained by quoting his own words to me in a letter:—

"These two wings were obtained from debris of the embankments of the Burwood Colliery railway, made up of the material taken from two tunnels which had to be made in the course of its construction. The floors of these tunnels are only three or four feet above the Dirty Seam of the Newcastle Series of Coal seams, and are practically identical with the geological horizon from which *Permoscarta mitchelli* Till. was collected. But the embankments are close to the sea, and frequently, during heavy storms, suffer much damage from the waves beating upon them. This periodical damage has been mostly repaired with chitter (impure coal and bands of mudstone, etc.) and other refuse from the Burwood Colliery. Thus it is possible that these two wings (or one or other of them) came from the Burwood Coal Seam horizon, which is from one hundred to one hundred and twenty feet above the Dirty Coal Seam; but it is much more likely that they came from the lower horizon before mentioned.

"The bricky or burnt condition of the material in which the wings occur was produced by the spontaneous combustion of the material of which the embankments have been composed. This kind of combustion always happens in heaps of coal or of chitter after exposure for a lengthened period of time to atmospheric influences.

"It is unfortunate that these wings were not found *in situ;* for, if they had been, we would know exactly where to look for others belonging to the same geological horizon, a matter of great scientific importance considering the uniqueness of each of these wings."

The material in which the fossils occur is of a bright brick-red colour and very hard, reminding one of the bricks made by the Romans and used by them in ancient Roman buildings in England. The material has a shallow conchoidal fracture, for the most part very smooth. The wings are associated with plentiful remains of small fronds of a species of *Glossopteris*. The smaller wing, in fact,

is preserved right in the middle of one such frond, as may be seen from Plate xxxv., fig. 2. Owing to the material having been burnt, the impressions, both of the wings themselves and of the *Glossopteris* fronds, are very hard and very clearly marked. The embankment from which they were taken is at Merewether Beach, about four miles south of Newcastle, N.S.W.

These two wings were lent to me by Mr. Mitchell and have been in my possession for about two years, during which time I have studied them frequently, but found it difficult to determine with certainty their systematic positions. I should doubt if two more unique types of insect wing have ever before been found. Moreover, the very simplicity of their venation adds to the difficulty of placing them. On the one hand, they stand far apart from all known Carboniferous forms; while, on the other, they show no close affinities with any known Mesozoic, Tertiary or Recent forms. I have finally decided to place both wings within the Order Hemiptera, of which early representative types have already been discovered in the Upper Permian of Newcastle and Belmont in the shape of the two genera *Permofulgor* and *Permoscarta*. If my placing of these two fossils is correct, then it still remains true that, of all the wings so far discovered in these beds, there is not a single type that does not belong either to the Hemiptera or to the Mecoptera.

While further discoveries in these beds should most certainly increase the number of Orders represented in Australia at that period, one cannot but admit that it already appears evident that the dominant Insect Fauna of the Period was a mixed one of Plant Hoppers and Scorpion-flies. Such a combination can only be found in Australia, at the present day, in the damp bottoms of shady gullies, or along the shady southern slopes of steep hillsides, where dews fall heavily and remain long undispersed by the sun's rays. In such localities, Cockroaches should most certainly occur, if they had reached Australia at the time these insects were fossilized; so also should Megaloptera, and perhaps some early forms of Planipennia. Coleoptera, if evolved by then, would most certainly have been present also; the absence of this Order from the Upper Permian of New South Wales is one of the most striking facts about this horizon, considering how abundant they are, and how highly evolved, in the Upper Trias of Ipswich, Q.

Before going on to describe the fossils themselves, I wish to thank Mr. Mitchell for the opportunities he has given me for studying these and other fine insect fossils in his collection, and also to draw attention to the magnificent work which he has accomplished, and is still accomplishing, in spite of his advanced years, in the difficult and painstaking exploration of the Belmont and Newcastle Beds,—in which, as I know from personal experience, one has often to work for days on end without getting a single wing as a reward. I have also to thank Mr. W. C. Davies, Curator of the Cawthron Institute, for the two excellent photographic enlargements of the fossil wings, which are reproduced in Plate xxxv., figs. 1 and 2.

Order **HEMIPTERA.**

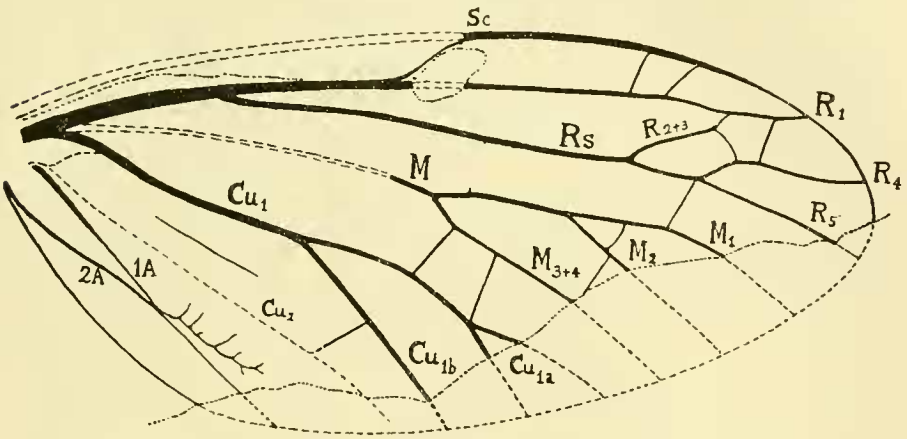
Suborder **Palaeohemiptera.**

Family PROSBOLIDAE.

Genus MITCHELLONEURA, n.g. (Plate xxxv., fig. 1; Text-fig. 1.)

Hindwing: Shape moderately broad and rounded at apex; veins very strongly built, but the wing membrane delicate. Sc short, fused with R_1, ending up at about half-way along the costal margin. R_1 very strongly formed, slightly

curved, ending up a little before apex. Rs arising at about one-fourth from base as a strongly built vein diverging gradually from R_1 and remaining unbranched until about one-fourth from apex; it then gives off an anterior branch, R_{2+3}, which runs obliquely upwards to join R_1, while the main portion R_{4+5}, runs straight on for a short distance and then forks into R_4 and R_5, which end up just above and below the apex respectively. M arises from R close to base and runs obliquely across the wing, sub-parallel to Rs; it remains simple to half-way, when it forks into M_{1+2} and M_{3+4}, the former again forking into M_1 and M_2, the latter remaining unforked. Cu_1 a very strong vein running obliquely and slightly divergingly below M to about one-third from base, where it forks into Cu_{1a} and Cu_{1b}, the former of which is again forked. Cu_2 only just indicated as a weak furrow vein. Anal area (possibly partly overfolded) with 1A and 2A present; 1A straight and simple, 2A waved.



Text-fig. 1. *Mitchelloneura permiana*, n.g. et sp. Hindwing. (x 6.7)

1A, 2A, anal veins; Cu_1, first cubitus, with its branches Cu_{1a} and Cu_{1b}; Cu_2, second cubitus; M, media, with its branches M_1, M_2 and M_{3+4}; Rf, main stem of radius; Rs, radial sector, with its branches R_{2+3}, R_4 and R_5; Sc, subcosta.

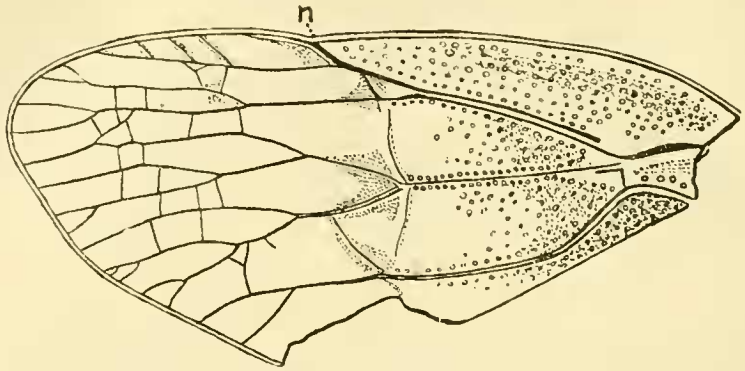
Genotype, *Mitchelloneura permiana*, n. sp.

Horizon. Upper Permian of Newcastle, N.S.W.

The generic name is given as a dedication to the discoverer of the Newcastle and Belmont fossil insects, Mr. John Mitchell.

Affinities: The short Sc, fused with R, the manner of branching of Rs and M, and especially the forked Cu_{1a}, indicate the Hemipterous nature of this remarkable fossil. The only known wing with which it seems to have any close affinity is that of *Prosbole hirsuta* Koken (Text-fig. 2) from the Upper Permian of the Kama River, Russia. This fossil is a forewing. The differences between it and *Mitchelloneura* are of the kind one would expect in comparing fore and hind wings of two fairly closely related insects. For example, *Prosbole* shows a definite beginning of the division of the wing into *corium* and *membrane*, as seen in most of the Heteroptera, and the corium is strongly tuberculated. In conjunction with this, it will be seen that a definite *node* is present just beyond

half-way along the costa, where Sc ends. It is certain that the hindwing of *Prosbole* had no division into corium and membrane, and also had no node, since neither of these specialisations has ever been developed in a hindwing of the



Text-fig. 2. *Prosbole hirsuta* Koken, hemelytron, after Handlirsch. (x 2.1). Upper Permian, Kama River, Russia. *n*, node.

Order. The general resemblance of the venational scheme in the two genera is evident enough, though the number of branchings of Rs and M is different. The general arrangement of the system of cross-veins is also similar, though *Prosbole* has more of them than *Mitchelloneura*. Characters shared in common by the two wings are:—the short Sc, fused with R, and ending up in a characteristic manner about half-way along the wing, the nearly straight R_1, with cross-veins connecting it with the costa, the general arrangement of Rs, M and Cu_1 with respect to one another, and their lack of branching or cross-veins before half-way along each of their lengths, the form of the fork of Rs, in which R_{2+3}, arches up anteriorly, while R_{4+5} runs almost straight on, the form of the fork of M_{1+2} and the forking of Cu_{1a}. On the other hand, R_{2+3} does not join up with R_1 in *Prosbole*; R_{4+5}, has an extra branch; M_2 is forked; and M_{3+4}, instead of being a simple vein, not only forks, but has an extra fork on M_4.

It seems reasonable to conclude that, if the forewing of *Mitchelloneura* were known, it would be sufficiently like that of *Prosbole* to allow the two genera to be placed within the same family, though not in the same genus.

MITCHELLONEURA PERMIANA, n. sp. (Plate XXXV., fig. 1; Text-fig. 1.)

Hindwing: Total length, 17 mm; greatest breadth of specimen, 7 mm., representing a total width for the complete wing of about 7.5 mm.

The specimen is the mould or counterpart of a right wing, as is proved by the fact that R_1, Cu_1 and the anal veins are concave, while M is convex in the fossil impression. It rests in a slightly irregular hollow of a piece of hard burnt shale having a conchoidal fracture; the apex is to the left. Text-fig. 1 gives a diagram of the wing with the apex turned to the right, and the missing parts restored by the dotted lines. The softness and delicacy of the wing membrane is indicated by numerous signs of stretching and rucking present in the fossil. Except in some of the higher Holometabola, forewings having such a delicate structure of the membrane are seldom met with; and, as this is a wing of considerable size and very strong venation, this condition of the membrane

is strong evidence that we have to deal with a hind wing. The absence of a definite clavus points in the same direction.

Specific characters in the venation are the positions of the cross-veins: two, close together, connect R_1 with the costal margin; a curved cross-vein connects R_{2+3} with R_4, and, just beyond it, a straight one connects R_4 with R_1; another cross-vein descends from the fork of R_{4+5} on to M_1; a short curved cross-vein bridges the fork between M_1 and M_2, and, almost exactly below it, a straight cross-vein runs from M_2 to M_{3+4}. This latter vein is connected with Cu_{1a}, by two straight cross-veins, the more distal of which, placed slightly obliquely, falls directly on to the fork of Cu_{1a}; just before the middle of its length, Cu_{1b} sends a straight cross-vein to Cu_2.

The peculiar formation of vein 2A is very noticeable. Probably owing to an overfolding of the weak membrane, this vein appears to cross 1A at about the middle of its length, and then begins to give off a series of short, irregular stump-veins which quickly fade away into the membrane without joining up anywhere or reaching the wing margin. Possibly these are the last remnants of a weak archedictyon.

The missing parts of the wing are: the basal half of the costal margin, a small piece cut out of the middle of R_1, just distad from the free end of Sc, most of the basal half of M, almost the whole of Cu_2, and a narrow, irregular portion of the wing along the posterior margin, from just before the end of 1A right round to the apex.

Type in Mr. John Mitchell's Collection.

Locality.—Burnt shale from the embankment of the railway at Merewether Beach, near Newcastle, N.S.W.

Suborder **Homoptera.**

Division *STERNORRHYNCHA.*

Family LOPHIONEURIDAE, fam. nov.

A monotypic family, with characters as given for the genus *Lophioneura* below.

Genus LOPHIONEURA, n.g. (Plate xxxv., fig. 2; Text-fig. 3.)

Forewing: Size very small, shape elongate oval, about three times as long as broad. R and Cu_1 forming two high, sharp ridge-veins, strongly convex, and much stouter than the other veins, which are all flat and weakly formed. Sc short, ending on costal margin at about one-third from base. R arising from middle of base, and having the basal portions of M and Cu_1 fused with it; R_1 running nearly straight, obliquely upwards, to end on the costa about three-fifths from base; Sc and R_1 are roughly parallel. Rs a weak vein, arising from R at about one-sixth from base, and running in a gentle double-curve to beyond the level of the end of R_1, where it forks widely; the upper fork, R_{2+3}, runs parallel to R_1 to the costa; the lower fork, R_{4+5}, runs obliquely downwards to end up at apex. M arises from R a little before origin of Rs, and runs below it in a single concave curve nearly to the level of the end of R_1, when it forks similarly to Rs; the upper fork, M_{1+2}, arches upwards, and then curves to run below and parallel to R_{4+5} to a point well below apex; the lower fork, M_{3+4}, makes a very weak double-curve, and ends on the posterior margin a little beyond the level of the fork of Rs. Cu_1 arises from R a little before M, and runs as a high ridge to about half-way along the wing; this part of it makes a single continuous curve below and sub-parallel to M. At the point

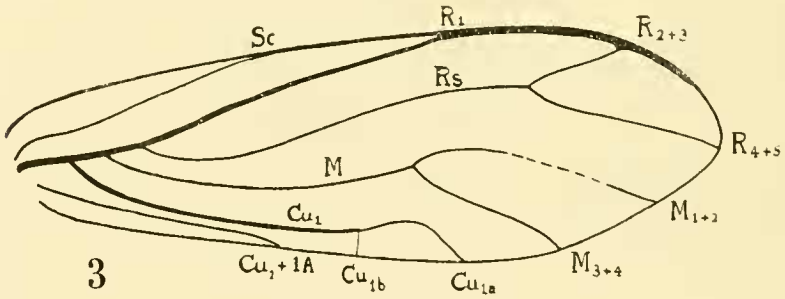
where the high ridge ceases, Cu_1 sends off a short branch, Cu_{1b}, directly to the wing-margin below it, while the main part, Cu_{1a}, becomes a weak vein, forming a well defined arch upwards beneath the fork of M, and then curving down to end up on the posterior margin at the same level as the end of R_1 on the costa. In the narrow space between Cu_1 and the posterior border, there lies a short, concave vein arising basally below R; this is probably $Cu_2 + 1A$, fused together. There are no claval veins present, the true clavus being reduced to the very narrow strip lying between this last vein and the posterior border.

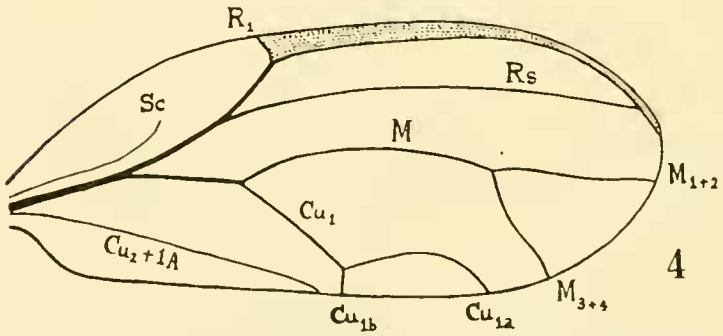
The membrane of the wing is evidently very tough, its impression completely obliterating that of the frond beneath it; there is an appearance of a very fine granulation all over it. (Plate xxxv., fig. 2).

Genotype. *Lophioneura ustulata*, n.sp.

Horizon. Upper Permian of Newcastle, N.S.W.

The generic name was suggested by the strongly formed ridges of the veins R and Cu_1. (Greek λοφιά = a ridge).





Text-fig. 3. *Lophioneura ustulata*, n.g. et sp. Forewing. (x 16.7).
Text-fig. 4. Forewing of a large undescribed species of Psyllid from New Zealand, (expanse about 10 mm.).
For venational notation, *see* Text-fig. 1 above.

Affinities: In the complete fusion of the basal portions of M and Cu_1 with R, coupled with the small size, excessively simplified venational scheme and the very evident thickening of the costal margin from R_1 almost to apex, the forewing of *Lophioneura* shows very definite Sternorrhynchous characters,

though, at the same time, it is evidently of much more archaic formation than any type of Sternorrhyncha now known to exist. It is generally agreed that the *Psyllidae* are the most archaic of the existing Sternorrhyncha. Text-fig. 4 shows the forewing of an unnamed Psyllid of comparatively large size (expanse about 10 mm.) taken near Nelson, N.Z., which shows most of the archaic venational characters for the family. By comparing this with the venation of *Lophioneura* (Text-fig. 3) it will be seen that the following differences occur:—

(1) The Psyllid wing has become broader and more rounded; and, consequently, the costal margin has become strongly arched.

(2) In the Psyllid, Sc is degrading, and fails to reach the costal margin. (In some Psyllids, Sc is a short vein completely fused with the costa).

(3) The primary vein formed of the fused bases of R, M and Cu_1 is a strong ridge-vein equally in the Psyllid as in *Lophioneura*; but the amount of fusion of the three main stems which form it is much greater in the Psyllid, and there is a further fusion of the main stems of M and Cu_1, after leaving R, which is absent in *Lophioneura*. (In some Psyllids, however, this latter fusion is absent, M and Cu_1 leaving the primary vein at the same point).

(4) The origin of Rs from R_1 is placed much farther distad in the Psyllid, while the main stem of R has become much shorter and turns up more rapidly to join the costa. This last change is evidently correlated with the broadening of the wing.

(5) The very evident thickening of the costal margin in *Lophioneura*, which begins at the end of R_1 and reaches almost to the apex, is present in the same position in the Psyllid, but has become widened out into a coriaceous stigmatic area, broadest at R_1. The basal broadening of this area is again a change that is clearly correlated with the broadening of the wing.

(6) Rs has lost its fork. (If the position of the thickened costal area is a guide, it would appear that this has happened by suppression of R_{4+5}).

(7) M and Cu_1 have retained their forks, but that of M has widened in the Psyllid and altered in shape, while that of Cu_1 has altered very little indeed.

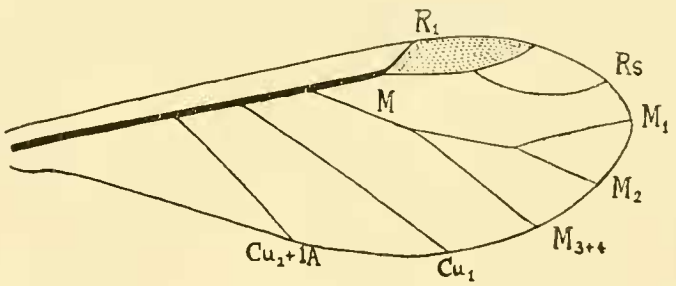
(8) While the vein $Cu_2 + 1A$ has altered little, the areas above and below it have broadened greatly. This again is clearly due to the general broadening of the wing.

I think that it will be admitted, from the above comparison, that the *Psyllidae* may be considered, as far as their forewing venation is concerned, to be direct descendants of the *Lophioneuridae*. Many authors have already pointed out that the Sternorrhyncha cannot be derived from the Auchenorrhyncha, owing to their possessing several more archaic characters than these latter. The Auchenorrhyncha have already been found in existence in the Newcastle Permian. We should naturally, then, expect to find the ancestors of the Sternorrhyncha existing alongside them, though the probability of such small wings being preserved is considerably less than in the case of the generally much larger Auchenorrhyncha. *Lophioneura* may, I submit, be legitimately considered to be a representative of this ancestral group.

From this same ancestral type, represented by *Lophioneura*, it is clear that, as far as the forewing is concerned, the *Aphiidae** can also be quite simply derived, though in a different direction from the *Psyllidae*. The line of evolu-

* *See* A .C. Baker, "On the Family Name of the Plant Lice." Proc. Ent. Soc. Washington, xxiii., No. 5., May, 1921, pp. 101-103, in which it is shown that the correct genitive of *aphis* is *aphios*, not *aphidos*, and hence the family name should be *Aphiidae*, not *Aphididae*.

tion leading to the *Aphiidae* must show a continuous tendency towards the narrowing of the wing-base, together with a steady movement of the points of origin of Rs, M and Cu_1 distad along the primary vein. Rs appears to be generally a simple vein in the *Aphiidae*, as in the *Psyllidae*. But, if we use the position of the thickened stigmatic area as a guide, it would seem that, in the *Aphiidae*, this simplicity has been attained by the suppression of R_{2+3}. The fact that the distal portion of Rs in the *Aphiidae* is concavely curved to the costa would also support this contention. Correlated with the narrowing of the wing basally, the primary vein in the *Aphiidae* becomes perfectly straight, and approaches near to the costa in position. Cu_2 + 1A, on the other hand, becomes fused with the primary vein, and moves upward, following the distal movement of Rs, M and Cu_1. In some forms an extra fork appears on M_{1+2}, but has not yet become fixed in every case. (I have seen this extra fork *on one forewing only*, not only in *Aphiidae*, but also occasionally in *Psyllidae*). Text-fig. 5 shows the typical venation of the forewing of an Aphid, for comparison with Text-figs. 3 and 4.



Text-fig. 5. Diagram of the venational scheme in the forewing of the Family *Aphiidae*, showing M with the extra branch present.
For venational notation, *see* Text-fig. 1 above.

It would seem, then, reasonable to recognise in *Lophioneura* a highly archaic Sternorrhynchous type, (probably standing quite close to the archetype of the group), from which, through the long period of geological time between the Upper Permian and the first appearance of the true *Psyllidae* and *Aphiidae*, changes along two different evolutionary lines have led to the venational types of these two families.

LOPHIONEURA USTULATA, n.sp. (Plate xxxv., fig. 2; Text-fig. 3.)

Forewing: Length, 5.7 mm; breadth, 1.9 mm.

The specimen is the cast of a complete right wing, lying longitudinally upon the midrib of a small frond of *Glossopteris* sp., the base of the wing being towards the apex of the frond, and 10 mm. from it. (*See* Plate xxxv., fig. 2). The impression is perfect, but for slight indistinctness of the basal portion of the costa and of a portion of M_{1+2}, where the rock appears to have been scraped. The costal margin is delicately formed from base up to end of R_1, but from there on almost to apex it is strongly formed, and appears to be made up of the true costa fused with R_1, which, in that case, must be assumed to run on well beyond its apparent termination on the costa. At the point where R_{2+3} ends up, this strong costal vein broadens out a little to meet it, and then runs strongly on for about two-thirds of the distance between the two branches of Rs, where it ends.

Type in Mr. John Mitchell's Collection.

Locality.—Burnt shale from the embankment of the railway at Merewether Beach, near Newcastle, N.S.W.

The specific name indicates the burnt condition of the rock on which the impression was found, with the addition of a diminutive in allusion to the small size of the wing (Latin, *ustus* = burnt).

The discovery of the two fossils described above leaves the known history of the Hemiptera in late Palaeozoic times in a very interesting condition. True Homoptera belonging to the Division Auchenorrhyncha have already been discovered in the Upper Permian, viz. *Permoscarta*, belonging to the *Scytinopteridae*, and *Permofulgor* representing the monotypic family *Permofulgoridae*; the former was found at Newcastle, N.S.W., the latter at Belmont, at a somewhat higher horizon. Thus we now know four very distinct types of Upper Permian Hemiptera from Australia, if my determinations of the systematic positions of these fossils are correct. To these may be added the two known Upper Permian genera from Russia, viz. *Prosbole* and *Scytinoptera*. We thus get the following classification for the Order in Upper Permian times:—

Suborder **Palaeohemiptera.**

A single family, *Prosbolidae*.
Genera *Prosbole* (Russia), *Mitchelloneura* (Australia).

Suborder **Homoptera.**

Division AUCHENORRHYNCHA.

Family *Scytinopteridae*.
Genera *Scytinoptera* (Russia), *Permoscarta* (Australia).
Family *Permofulgoridae*.
Genus *Permofulgor* (Australia).

Division STERNORRHYNCHA.

Family *Lophioneuridae*.
Genus *Lophioneura* (Australia).

The Suborder Heteroptera had apparently not yet been evolved. As I had previously pointed out, in dealing with the Upper Triassic family *Dunstaniidae*, which is the oldest known type of true Heteroptera, their origin is to be looked for in the Palaeohemiptera, from some type a little earlier than *Prosbole* itself (Tillyard, 1918, p. 589). The discovery of the genus *Mitchelloneura* shows that the ancestral type there postulated was probably present in Australia in Upper Permian times, just as the ancestors of the Upper Triassic Homoptera of Australia were already present there at that same period.

The fact that the Homoptera were already specialised into their two main Divisions in Upper Permian times indicates a considerably earlier origin in geological time for the Order Hemiptera as a whole. This indication is borne out by the occurrence, in the Upper Carboniferous of Commentry, of a fossil forewing, left unclassified by Handlirsch (1908, p. 325, and Atlas, Pl. xxxiv., fig. 1) which Professor Lameere and myself both agree, after studying the specimen itself, should stand close to the earliest beginnings of the Order, but definitely within it. This fossil is *Dictyocicada antiqua* Brongniart. We are thus led to envisage the Order Hemiptera as a highly specialised but exceedingly ancient offshoot of some more generalised Upper Carboniferous Order, which already possessed the stegopterous or roof-like manner of folding the wings. This Order must surely be the Protorthoptera of Handlirsch, in which so many diverse types are known to have occurred that they may well form

the starting-point, not only of the Hemiptera, but of many other Orders existing at the present day.

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HANDLIRSCH, A., 1908.—Die Fossilen Insekten. Leipzig.
(*Prosbole*, p. 390, and Atlas, Pl. xxxvii., figs. 24, 25; *Dictyocicada*, p. 325, and Atlas, Pl. xxxiv., fig. 1.)

TILLYARD, R. J., 1918.—Mesozoic Insects of Queensland. Part 4. Hemiptera Heteroptera: the Family *Dunstaniidae*. *Proc. Linn. Soc. N.S.W.*, vol. xliii., 1918, pp. 568-592, pl. lix.

Cawthron Institute, Nelson, N.Z.
August 9th, 1921.

EXPLANATION OF PLATE XXXV.

Fig. 1. *Mitchelloneura permiana*, n.g. et sp., hindwing. (x 6.7).

Fig. 2. *Lophioneura ustulata*, n.g et sp., forewing, lying upon a portion of a frond of *Glossopteris* sp. (x 16.7).